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Part of Paper #2

29 December 2003

Crystal J. Barnes
Examiner
United States Patent and Trademark Office
P.O. Box 1450
Alexandria, VA 22313

RE: Application Number 09/771,799

Dear Ms Barnes:

Thank your for your consideration regarding patent application 09/771,799. In review of your comments, it is clear that you discovered application inconsistencies. Your efforts are appreciated in discovering these inconsistencies. I trust the amendments enclosed clarify and correct those inconsistencies.

Again, after review of your comments regarding the application claims, I now have a better understanding of the USPTO requirements. I have reworked the claims for your review. Because I am a practicing mechanical / control engineer, patent law is not an area I consider a specialty and request a meeting with you to discuss the patent application and specifically the claim construction. As circumstances occur, I am temporarily local to the area while overseeing the building a pharmaceutical plant and may be reached at:

(301)963-1719

Please continue to send official correspondence to the address on record.

I have also included the Detailed Action Section of the Office Action along with my responses (as set off by text boxes and differing fonts). To address some of the comments, I have included a paper published by The Instrumentation, Systems, and Automation Society. This paper was awarded co-best paper at the Technology Exposition 2001, Houston, TX for its advancement of process control engineering. I trust these responses along with this paper will aid you in determining patentability of my application.

Thank you in advance for your assistance.

Sincerely

Robert H. Francis PE
President

Enclosures:
1 Detailed Action Section of the Office Action with Applicant Remarks
2 Amendment A
3 Francis, Robert H., "Asymptotic Approach Algorithm " ISA 2001 Technology Update, Volume LVI Part 1,The Instrumentation, Systems and Automation Society), Research Triangle Park NC, 2001, Page 111 to 120 along with USPTO form PTO/SB/08B.

Detailed Action

Information Disclosure Statement

1. The information disclosure statement filed 2001 April 12 fails to comply with 37 CFR 1.98(a)(2), which requires a legible copy of each U.S. and foreign patent; each publication or that portion which caused it to be listed; and all other information or that portion which caused it to be listed. It has been placed in the application file, but the non-patent literature document referenced to therein has not been considered.

> Agreed. The reference was included because the reference had been listed in another US patent. The examiners consideration is appreciated.

Drawings

2. The drawings are objected to as failing to comply with 37 CFR 1.84(p)(5) because they include the following reference sign(s) not mentioned in the description: reference numbers 42, 46, 50, 56, 60 and 62 in figure 2 are not mentioned in the specification. A proposed drawing correction, corrected drawings, or amendment to the specification to add the referenced sign(s) in the description, are required in reply to the Office action to avoid abandonment of the application. The objection to the drawings will not be held in abeyance.

> Agreed. Please see Attachment 1 for amendment

3. The drawings are objected to as failing to comply with 37 CFR 1.84(p)(4) because reference character "52" has been used to designate both "Set each element of Z stack to 0" and "Adjust K_{bias}" in figure 2. Also see page 11 2nd and 3rd full paragraphs. A proposed drawing correction or corrected drawings are required in reply to the Office action to avoid abandonment of the application. The objection to the drawings will not be held in abeyance.

> Agreed. Please see Attachment 1 for amendment

Specification

4. The disclosure is objected to because the following informalities: reference number 58 on page 11 end of 3rd full paragraph should be reference number 60. Appropriate correction is required.

> Agreed. Please see Attachment 1 for amendment

Claims Objections

5. Claims 1 and 2 are objected to because of the following informalities: claims numbers "A1" and "A2" should be "1" and "2" and the whereby clauses of both claims 1 and 2 should be changed to additional steps of the process. Appropriate correction is required

> Agreed. Please see Attachment 1 for amendment

Claims Objections 35 USC § 112

6. The following is a quotation of the second paragraph of 35 U.S.C. 112:

> The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the application regards as his invention.

7. Claim 1 is rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention.

8. Claim 1 recites the limitation "said analog controller's output" in step c of the claim. There is insufficient antecedent basis for this limitation in the claim.

Agree to Examiners points 6, 7, and 8. Please see Attachment 1 for proposed claim modification. Petitioner requests interface with Examiner to discuss and clarify claims that will meet the requirements of 35 U.S.C. 112.

Claims Objections 35 USC § 101

9. 35 U.S.C. 101 reads as follows:

> Whoever invents or discovers any new and useful process, machine, manufacture, or composition of matter, or any new and useful improvement thereof, may obtain a patent therefore, subject to the conditions and requirements of this title.

Claims 1 and 2 are rejected under U.S.C. 101 because applicant has filed to claim a practical utility that defines a "real world" context of use. Utilities that require further research to identify or reasonably confirm a "real world" context of use are not substantial utilities.

10. Claims 1 and 2 are rejected under 35 U.S.C. 101 because the claimed invention is not supported by either a specific, substantial, and credible asserted utility or a well established utility.

Examiner interprets that the claimed invention does not present any practical utility. Claims 1 and 2 recite the steps of a process for rapidly controlling a process variable to a set point without overshoot using a time domain polynomial feedback controller that is not applied to any practical utility

In reference to the examiner's points 9 and 10, proposed utility is currently in use. Please see copy of a paper presented to and published by *The Instrumentation, Systems, and Automation Society* (Francis, Robert H., "Asymptotic Approach Algorithm " ISA 2001 Technology Update, Volume LVI Part 1,The Instrumentation, Systems and Automation Society, Research Triangle Park NC, 2001, Page 111 to 120). Herein, the examiner will find:

> The first application for the asymptotic approach algorithm was on a fermenter in a brewing process. The fermentation optimizes when the process temperature is held just below the point where the enzymes are killed. However, the heating rate of the vessel does not affect the process. This application has the conflicting goals of rapidly moving the process variable to setpoint without the process variable overshooting the setpoint. The heating of this 6000-gallon fermenter had been controlled by traditional PID algorithm tuned for no overshoot. The Asymptotic Approach algorithm replaced the PID algorithm with the asymptotic approach algorithm configured for a small knee, the exponent, "*p*" term, was set to a relatively high value. The total batch cycle time for the 6000-gallon fermenter was reduced by ten percent when compared to the PID algorithm tuned for no overshoot. This reduction is a direct decrease to the product production cost and a direct increase in profitability.
>
> The asymptotic approach algorithm was also applied to a drum filling station. The drums are filled to approximately 620 pounds at a rate of 200 pounds per minute. This is an application where the process variable must be moved rapidly to the setpoint. Overshoot, while allowed by the customer (the customer receives more product for free), reduces profits and must be avoided. The asymptotic approach algorithm resulted in the drums being filled to the setpoint within the resolution of the scale, which is one pound.

These two examples are on currently operating production processes/machines at a manufacturer in Chicago, IL and are working to improve production by allowing each system to operate with lower tolerances. The fermenter application was first implemented in March of 2000 and the drum filler was implemented first in November 2000. The applicant trusts this reference meets the requirement for "real-world" context of use as well as a practical utility.

Claims Objections 35 USC § 103

11. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office Action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time of the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentablity shall not be negated by the manner in which the invention was made.

12 Claim 1 is rejected under 35 U.S.C. 103(a) as being unpatentable over USPN 4,948,950 to Rae in view of USPN 5,379,210 to Gruij et al.

As per claim 1 wherein a process for rapidly controlling a process variable to a setpoint without overshoot using a time domain polynomial feedback controller comprising the steps of: a. A means for calculating an error signal by comparing a process variable to a

setpoint; b. A means for setting said controller's output to zero if said error signal is negative; c. A means for calculating said analog controller's output using a user tuned time domain polynomial equation in a feedback configuration; d. A means for automatically converting to an integral correction for said setpoint maintenance based on user defined criteria; and e. A user selectable means for improving a bias tuning parameter automatically based on user defined criteria. Whereby said controller moves said process variable to said setpoint more rapidly in applications where overshoot is not allowed requiring less energy or materials necessary to achieve said setpoint.

The Rae reference discloses

(see figure 1 and column 3 lines 30-37, "The control means 22 .. a temperature sensing means 26 for sensing the actual temperature of cooking oil ... ")

(see column 3 lines 42-49, " The control means 22 ... a set point means 30 and is adapted to permit an operator to select the desired set point temperature for the deep fat fryer 20 ...")

(see column 3 lines 53-63, "The control means 22 ... a microprocessor 31 ... programmed with the new formula ... can turn on and off the heating means 23 through the relay means 32 ...")

(see columns 3-4 lines 64-2, "... shutting down the operation of the heat producing means 23 should the actual temperature of the cooking oil 25 exceed a certain high temperature limit...")

(see column 4 lines 11-15, "... a desired rate of change curve ... asymptotic to the selected set point temperature ... prevent adverse overshooting of the selected set point temperature.")

(see column 5 lines 1-22 "... the actual slope is compared with the target slope and if the actual slope is less than the target slope, the heat source 23 is energized (or merely remains energized) and, if the reverse is true, the heat source 23 is turned off ...")

Rae reference does not expressly disclose c. A means for calculating said analog controller's output using a user tuned time domain polynomial equation in a feedback configuration.

Rae discloses a "new formula" as follows: (see column 4 lines 16-24)

> In particular, a target curve of this invention is described by the formula Stb=(Tsp-T)•S where Stb is the target slope below the setpoint temperature or is the target rate of change of the temperature of the output heating effect of the heating means, Tsp is the desired setpoint temperature, T is the actual temperature of the output temperature effect and S is a selected constant that comprises a sensitivity factor.

Rae's "new formula" is different from the current invention as follows:

> The selected constant "S" is a linear multiplication factor resulting in a linear output to error. The current invention relies upon an nth order polynomial to rapidly change the final control element – and resulting process (measured) variable as said variable is approaching setpoint.

As shown in Figure 1, the current invention results in a significantly faster final control element response as the process variable approaches setpoint. By maintaining the final control element in a maximum output position for a longer time, the overall time for the process variable to approach setpoint is significantly reduced.

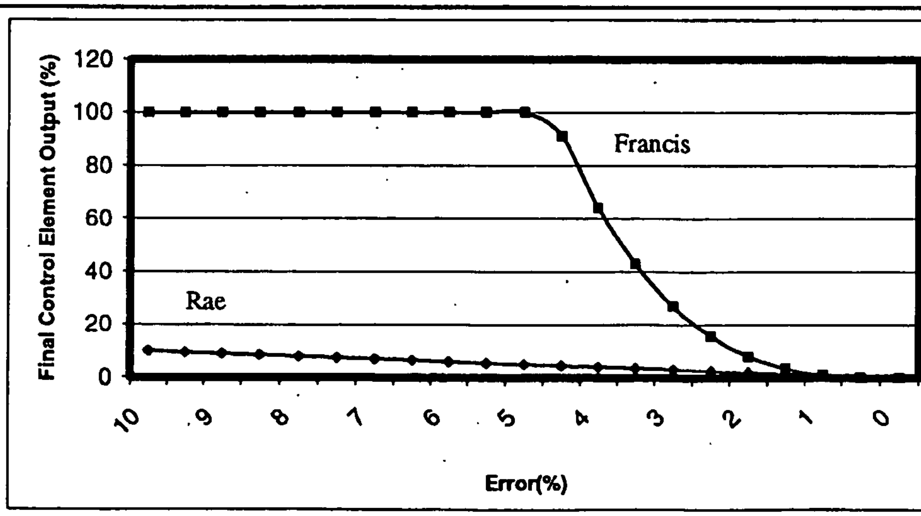

Figure 1: Final Control Element vs Error

The Gruji et al. reference discloses:

(see column 15 lines 66-68, "An input-output form for representing differential equations...")

(see column 16 lines 16-33, "A generalized linear differential equation ...")

(see column 17 lines 6-49, "The transfer matrix function for the input-output description of systems...)

(see column 21 lines 32-34, "The polynomial function is the accurate characteristic polynomial of the closed loop feedback control system.")

While Gruji discusses a polynomial function as applied to control, the discussion is under "2.1 LINEAR INPUT-OUTPUT DIFFERENTIAL EQUATION FORM" (see column 15 line 64). Gruji's reference "The polynomial function is the accurate characteristic polynomial of the closed loop feedback control system" is correctly stated as it relates to linear systems. The primary key to allow for this application is the system demonstrates or may be mathematically approximated as a linear system. Unfortunately most liquid processes are not linear; therefore these techniques require significant analysis and computing power to implement.

Gruji is applying well-understood linear system control theory in development of a state-space matrix for generation of a characteristic polynomial. Gruji does continue to teach the natural tracking controller through state-space variable development and derives a controller that this applicant believes may be applied to non-linear systems, however, the matrix algebra understanding and analysis required to implement the natural tracking controller is significant. These analyses are beyond the typical mathematical realm of a typical process control technician forcing engineers to execute both its implementation and maintenance.

The current invention differs from Gruji as follows:

1. The current invention has been successfully implemented on a non-linear system as a simple polynomial that is easily understood by technicians who have successfully completed a high school algebra course.
2. The current invention is managed/maintained in a similar manner as the PID – the main analog controller in industry.

At the time the invention was made, it would have been obvious to a person of ordinary skill in the art to further define the control means taught by the Rae reference with the natural tracking controller taught by the Gruji et al. reference.

The control system proposed by Rae is applied to a deep fat fryer which, if it were to be modeled mathematically, is a non-linear system. As aforementioned, Gruji's statement: "The polynomial function is the accurate characteristic polynomial of the closed loop feedback control system" is discussed as applicable to a linear system (mathematically). Many college senior texts reference the differences between linear and non-linear systems and that the characteristic control equations developed as control system solutions may not be equally applied between linear and non-linear systems. Therefore, a senior process control practitioner would not attempt to combine the two references and, if he made the attempt, the resulting system would be inoperable.

One of ordinary skill in the art would have been motivated to modify the control means with the natural tracking controller so that the behavior or the output of the control system was optimized with relatively minimal knowledge of the structure of the system being controlled.

While the current invention is very simple and what is simple should be obvious, the aforementioned paper presented to the ISA (the primary international technical society for process control engineering) was co-awarded best paper presented at the ISA Technology Exposition 2001 for best meeting the goals of the ISA. These goals included advancement of process control technology. The invention is intended to reduce the resources that are required to move a process (measured) variable to a setpoint without overshoot; a primary concern of a process control engineer.

The applicant therefore presents, while the simplicity of the invention is one of its main advantages, it has not been obvious to the engineering community primarily focused on process control for the 75 years of ISA's existence.

Attachment 1

Amendment A

Best Available Copy

Attachment 2

Asymptotic Approach Algorithm

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KEYWORDS

Process Control Algorithm, Batch Control

ABSTRACT

The asymptotic approach algorithm is a time-domain feedback type process controller utilizing a properly tuned polynomial equation to calculate the controller output. Its applications include those where the process variable must quickly move to and operate at the process setpoint without exceeding that setpoint (overshoot). The error (setpoint – process variable) is mathematically operated on by a polynomial equation. The result is the process measurement approaches the setpoint by following a polynomial curve. For applications requiring setpoint maintenance, a modified integral function is included to ensure the process variable is held at the setpoint over time.

INTRODUCTION

In batch process control applications, it is usually necessary to rapidly move the process variable to a setpoint but not allow that process variable to overshoot (or undershoot) the setpoint (i). Batch cycle times are reduced by minimizing the time required to move the process variable to the setpoint.

In some processes, process quality may be damaged if the process variable exceeds setpoint. In other processes, such as exothermic, unsafe conditions can occur with process variable overshoot. This process operation has two contradictory functions: to rapidly change the process variable when the process variable is far from the setpoint and to slowly change that variable when near the setpoint (ii)(iii)(iv). This is done with the final control element at 100 percent until the process variable is within a few units of the setpoint at which time the final control element rapidly moves to 0 percent.

A number of control strategies have been use to for this application, including: Proportional-Integral-Derivative (PID), Ramp-Soak, and Model Based controllers. Unfortunately, each of these controllers has drawbacks in trying to meet the above goals: inefficient response, no safeguards against overshoot, or significant complexity.

CURRENT CONTROL STRATEGIES

PROPROTIONAL-INTEGRAL-DERIVITIVE (PID) CONTROLLERS

Historically, process control engineers have employed a PID algorithm tuned for no overshoot to move the process variable to setpoint while not allowing overshoot. The downside of using this PID algorithm configuration is that significant time is required for the process variable to reach the setpoint because it reduces the final control element from 100 percent much sooner than optimum for minimum batch cycle times. Thus the cost to produce the product increases because the time to produce the product increases. Another drawback to the PID method is that this method does not include safeguards against process variable overshoot, because the controller output may remain open after the process variable exceeds setpoint resulting from the integral function.

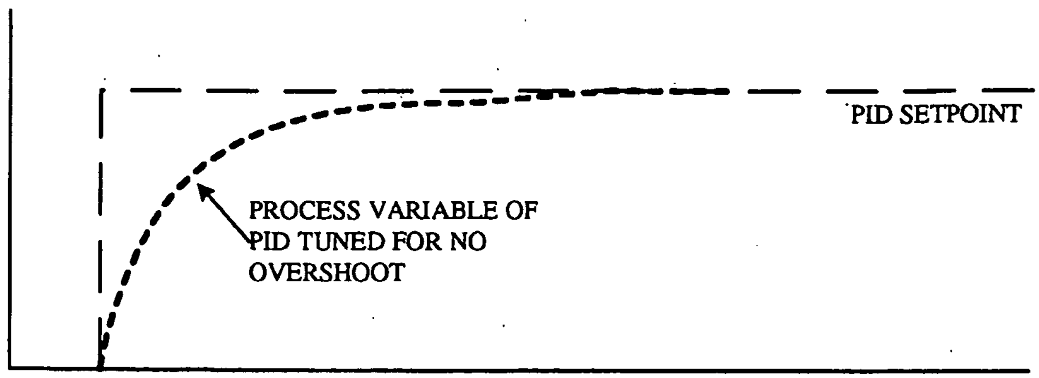


Figure 2: Traditional PID Process Variable Response

Another implementation of the PID includes forcing the controller output to MANUAL until the process variable reaches a percentage of the setpoint, say 80% of setpoint, switching to AUTOMATIC mode at this point and controlling in AUTOMATIC from there. This method approaches the aforementioned goals. However, it has the controller in MANUAL and thus not able to quickly react to unexpected process disturbances and still does not ensure the process variable stays below setpoint. Note: While this technique is seldom published, it is widely utilized in actual applications.

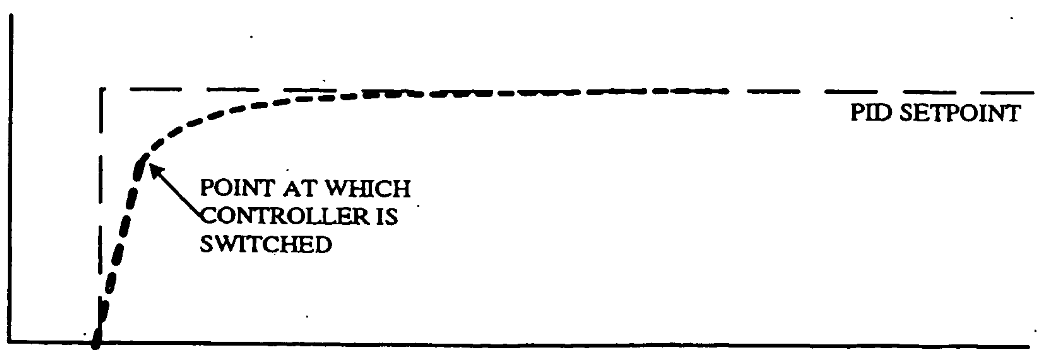


Figure 3 PID Override Performance

Another PID algorithm implementation includes an override of the integral constant – setting the integral constant to 0 until the process variable is close to the setpoint (v). This method provides better resistance to overshoot than the standard PID algorithm but does not include safeguards against overshoot.

RAMP-SOAK (SETPOINT CHARACTIZATION) CONTROLLERS

Ramp-soak controllers characterize the setpoint ascent (dissent) from the current value to the desired final setpoint by "ramping" the physical controller setpoint (vi). The advantage of this method is that the process variable is tightly controlled as the process variable moves to the final setpoint when the controller is properly tuned. However, the minimum time required is still not achieved and (See Fig. 2) the process variable may overshoot.

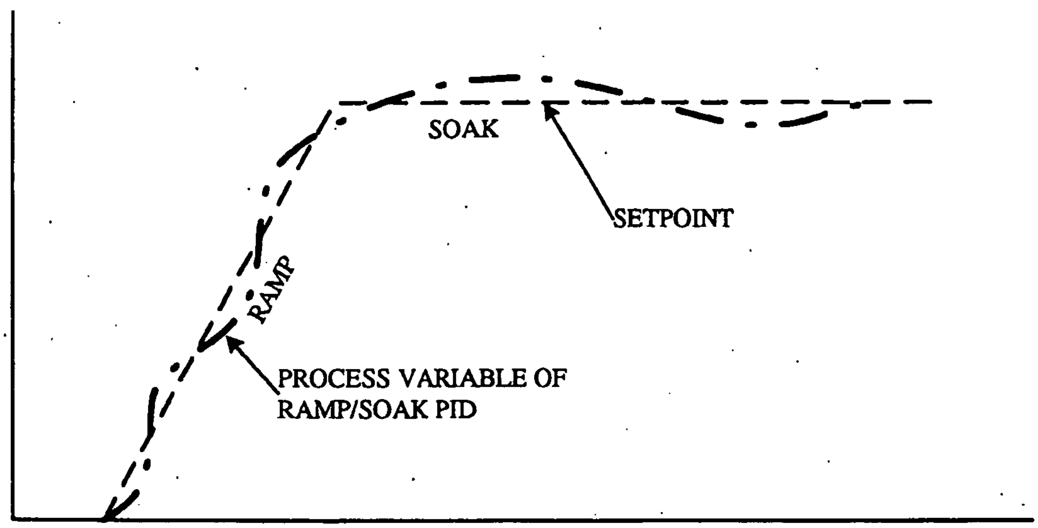


Figure 4: Ramp-Soak Process Variable Performance

MODEL BASED CONTROLLERS

Model based controllers, for example: Dahlin's Algorithm, Model Predictive Control (vii) and Generic Model Controller (GMC) (viii), utilize advanced control algorithms to "model" (hence the name) or characterize the optimum operation of the process. The current process conditions are compared to that model and final control element adjustments are made to achieve the ideal conditions as defined by the model. Model based controllers show great promise in the process control industry. However, these controllers generally are mathematically rigorous (ix). (The details are beyond the scope of this text. For detailed discussions regarding general model based type controllers, please refer to Lee and Sullivan (8).) These controllers also require significant computing resources and thus require significant cost (8)(x). These controllers are also based upon a model developed by an engineer at a specific time. If the engineer is unable to accurately predict the way the process will change over time due to equipment degradation, environmental changes or other factors, suitability of the model is compromised.

Another drawback of model based controllers is that senior control specialists are required support and maintain the controller. Many factories are outsourcing these control resources, increasing response times to production failures while the control specialist is accessing the factory. In this situation, the standard mechanic must request an outside control specialist when a controller related failure occurs if he is unfamiliar with that controller. This specialist may not be available until the next day. Thus the controller life cycle cost increases because the factory must have high-level control system support on staff or risk down production. Either situation drives up overall product production cost.

ASYMPTOTIC APPROACH ALGORITHM (PATENT PENDING)

IDEAL CONTROLLER RESPONSE

When a process variable is to be moved from its current position to a new setpoint, the ideal process variable response is a unit step function, except in cases where the process variable rate of change must be controlled. Unfortunately a true unit step function process variable response is not obtainable using current technology. An obtainable system response is one in which a small "knee" occurs where a rapidly changing process variable becomes close to the setpoint.

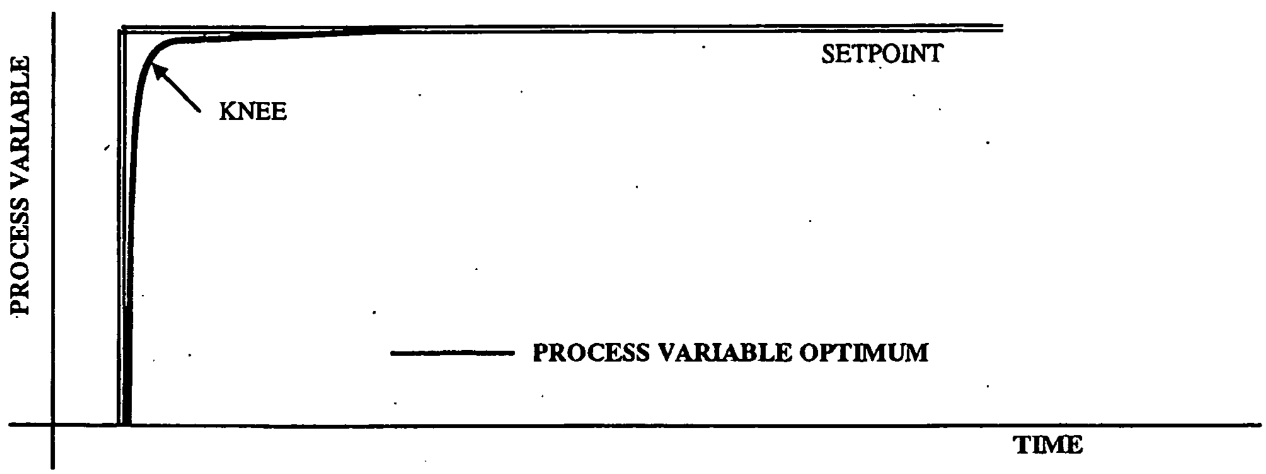


Figure 5: Ideal Process Variable Performance

The shape of this desired curve is one of an inverted polynomial equation having the form:

$$Y = A(x)^P + B(x) - C \qquad (1)$$

ASYMPTOTIC APPROACH ALGORITHM DESCRIPTION

BASE CALCULATION

When the above polynomial equation is applied to process control applications, the error is used as the "X" term and the output is used as the "Y" term. The equation takes the form of:

$$Output = K_a(Error)^P + K_b(Error) - K_{Bias} \qquad (2)$$

where:

K_a	is	Term 1 Gain (unitless)
P	is	Polynomial Term (unitless)
K_b	is	Term 2 Gain (unitless)
K_{Bias}	is	Output Bias (unitless)

The desired inverted polynomial equation results with the process variable following the inverted polynomial equation approach to setpoint.

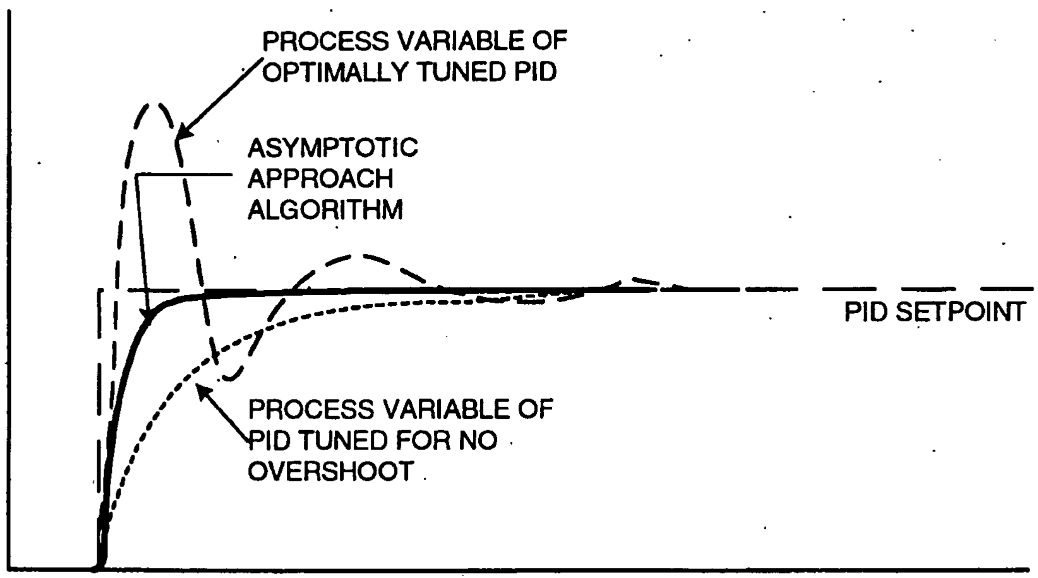


Figure 6: Different Controller Performance Curves

If the P term is odd (3, 5, 7,...), the output will be 0 if the error is negative. However, this is not the case if the P term is even. Therefore, a comparison function, inserted between the error calculation and the polynomial calculation, is required in the algorithm to ensure the error is positive. This guarantees the controller is 0 if the error is ≤ 0.

In systems containing non-negligible time delays between final control element change and process variable reactions, small overshoots will occur while this dead time is moving through the control loop. To counteract the dead time, a bias is subtracted in the polynomial equation, the constant term, forcing the output to 0 in time to prevent overshoot. Because this constant value may change over time with equipment degradation, environmental changes or other factors, an automated method to improve the bias value is included.

MODIFIED INTEGRATING OUTPUT ADJUSTMENT

After the setpoint is initially moved from its starting point to the final setpoint, a bias typically remains. To overcome this bias, the error signal is integrated over time and added to the output. This is similar to

the integral function of the PID algorithm with a significant difference: if the process variable exceeds the setpoint, either high or low, the accumulated integral value is set to 0.

Traditional PID algorithms suffer from integral wind-up. Integral wind-up is when the integration history, the error term integrated over time and added to the output, causes the process variable to move beyond the setpoint. Integral wind-up is the process controller equivalent to mechanical inertia. This inertia is often undesirable whether in a mechanical system or in a process control system. By setting the accumulated integral history to 0, the integral contribution to the output is temporarily interrupted; the inertia has the brakes applied and stops.

Most controllers include Anti-Reset-Wind-up methods to minimize the inertia problem. However, many of the controller methods activate only when the output is outside predefined limits (xi); for example, outside 0% and 100%. While other methods are more proactive in preventing overshoot, these methods allow the controller output to remain greater than zero in overshoot or undershoot conditions.

ASYMPTOTIC APPROACH OPERATIONAL DESCRIPTION:

BASE CALCULATION

If the measured value is less then setpoint for reverse acting processes or the setpoint is less than the measured value for direct acting processes, the controller output is calculated:

1. $Error = (Setpoint - Measurement)$ for reverse acting processes or (3)
   $Error = (Measurement - Setpo\text{int})$ for direct acting processes. (4)
2. If $Error$ is less than 0 set the $Output$ to 0.
3. $Output = K_a(Error)^P + K_b(Error) - K_{Bias}$ (5)
4. If the $Output$ is greater than 100%, set $Output$ to 100%
5. If the $Output$ is less than 1%, set the $Output$ to 0.
6. If the $Error$ is less than E_i (process variable units) quantity for E_t (seconds) time, check output bias quality as follows:
   - If $Error$ is greater than K_{Bias_adj}, $K_{Bias\_New} = K_{Bias} + (\frac{Error}{2})$ (6)
   - Set K_{Bias} to K_{Bias_New}
7. At same time point as Step 5 above, initiate modified integration output adjustment.
   where:

E_i	is	Error at which integral correction initiates (process variable units)
E_t	is	Time delay after E_i is reached before integral correction initiates (seconds)

Otherwise, the $Output$ is set to calculated $Output$ in 2.

If the measured value is greater than setpoint, the output is set to 0 and the integral stack is cleared by setting all registers to 0.

MODIFIED INTEGRATING OUTPUT ADJUSTMENT

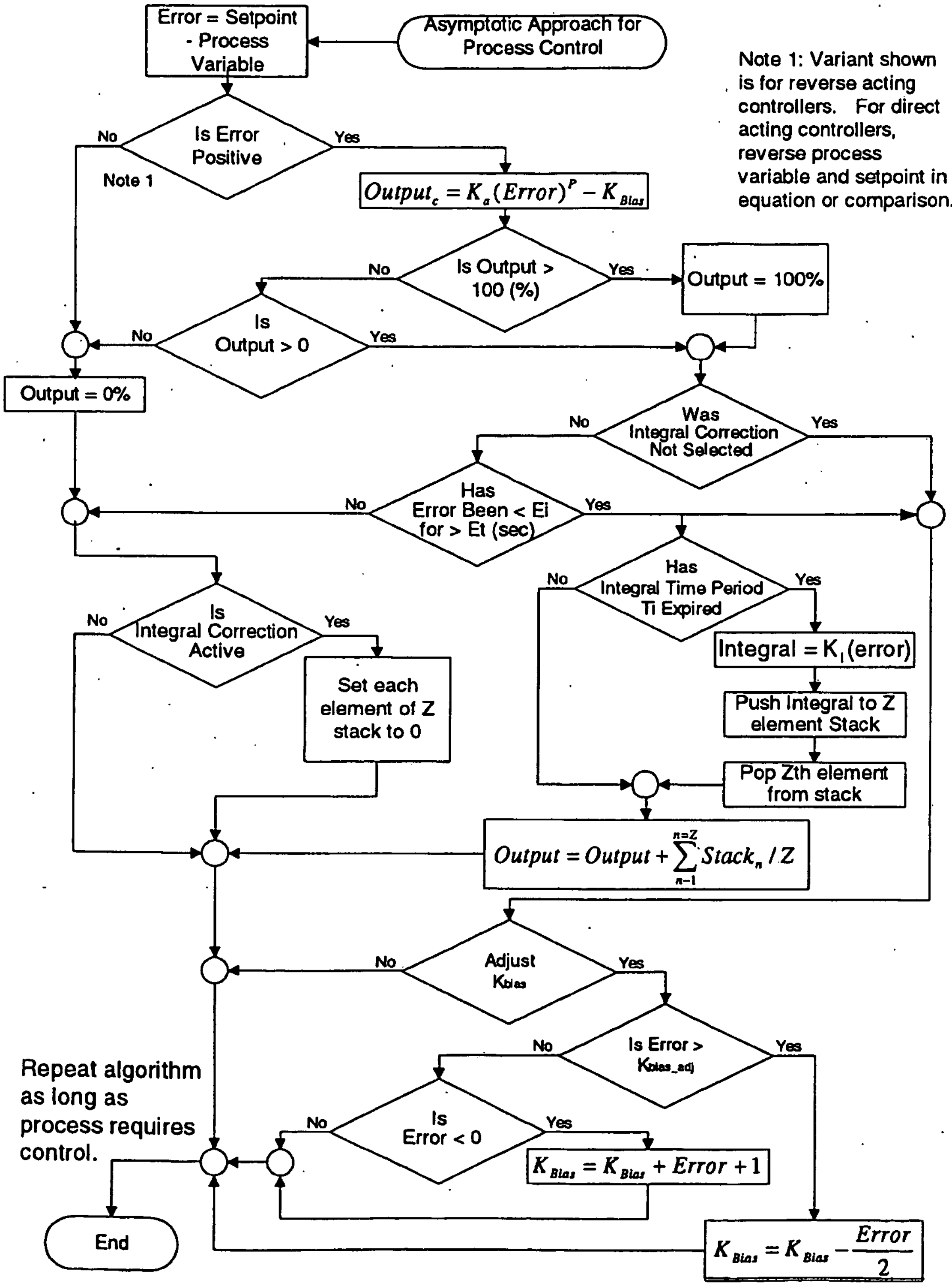
Each integral time interval I_t, an integration value is calculated:

$$Integral = K_i(error) \tag{7}$$

This integration value ($Integral$) is pushed on to a **Z** element First-In-First-Out (FIFO) error correction stack. The Z^{th} element of the stack is popped to prevent the stack from saturating.

Each stack register is added to the *Output*. The final control variable percentage is increased above the *Output* calculated in 2 to compensate for unidentified dynamic system disturbances.

FLOW CHART
(Patent Pending)
The following defines the asymptotic approach algorithm:



RESULTS

The first application for the asymptotic approach algorithm was on a fermenter in a brewing process. The fermentation optimizes when the process temperature is a held just below the point where the enzymes are killed. However, the heating rate of the vessel does not affect the process. This application has the conflicting goals of rapidly moving the process variable to setpoint without the process variable overshooting the setpoint. The heating of this 6000-gallon fermenter had been controlled by traditional PID algorithm tuned for no overshoot. The Asymptotic Approach algorithm replaced the PID algorithm with the asymptotic approach algorithm configured for a small knee, the exponent, "*p*" term, was set to a relatively high value. The total batch cycle time for the 6000-gallon fermenter was reduced by ten percent when compared to the PID algorithm tuned for no overshoot. This reduction is a direct decrease to the product production cost and a direct increase in profitability.

The asymptotic approach algorithm was also applied to a drum filling station. The drums are filled to approximately 620 pounds at a rate of 200 pounds per minute. This is an application where the process variable must be moved rapidly to the setpoint. Overshoot, while allowed by the customer (the customer receives more product for free), reduces profits and must be avoided. The asymptotic approach algorithm resulted in the drums being filled to the setpoint within the resolution of the scale, which is one pound.

CONCLUSION

The Asymptotic Approach algorithm is not a complete replacement for PID or other algorithms. For example, the PID algorithm will still provide the minimum integrated absolute error (xii) in continuous control applications that can tolerate overshoot. However, Asymptotic Approach does provide significant advantages in applications that cannot tolerate overshoot: near ideal response, safeguards against overshoot, maintaining the process variable under automatic control throughout the batch and economical to deploy.

BOTTOM LINE

The Asymptotic Approach algorithm provides the best balance of ideal response, reduced production cycle times, and economic implementation of currently available control strategies in applications where overshoot must be prevented. The result is the Asymptotic Approach algorithm provides the best value for control system expenditures in these applications.

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viii Lee, P. L., and G. R. Sullivan, "Generic Model Control (GMC)," Computers and Chemical Engineering, 12(6), 573-580, 1988
ix Wade, Harold L., "Model Based Control", Regulatory and Advanced Regulatory System Development, Instrument Society of America, Research Triangle Park, North Carolina, 1994, Page 211
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xii. McMillan, Gregory K., "Fundamentals", Tuning and Control Loop Performance, Third Edition, Instrument Society of America, Research Triangle Park, North Carolina, 1994, Page 47,69

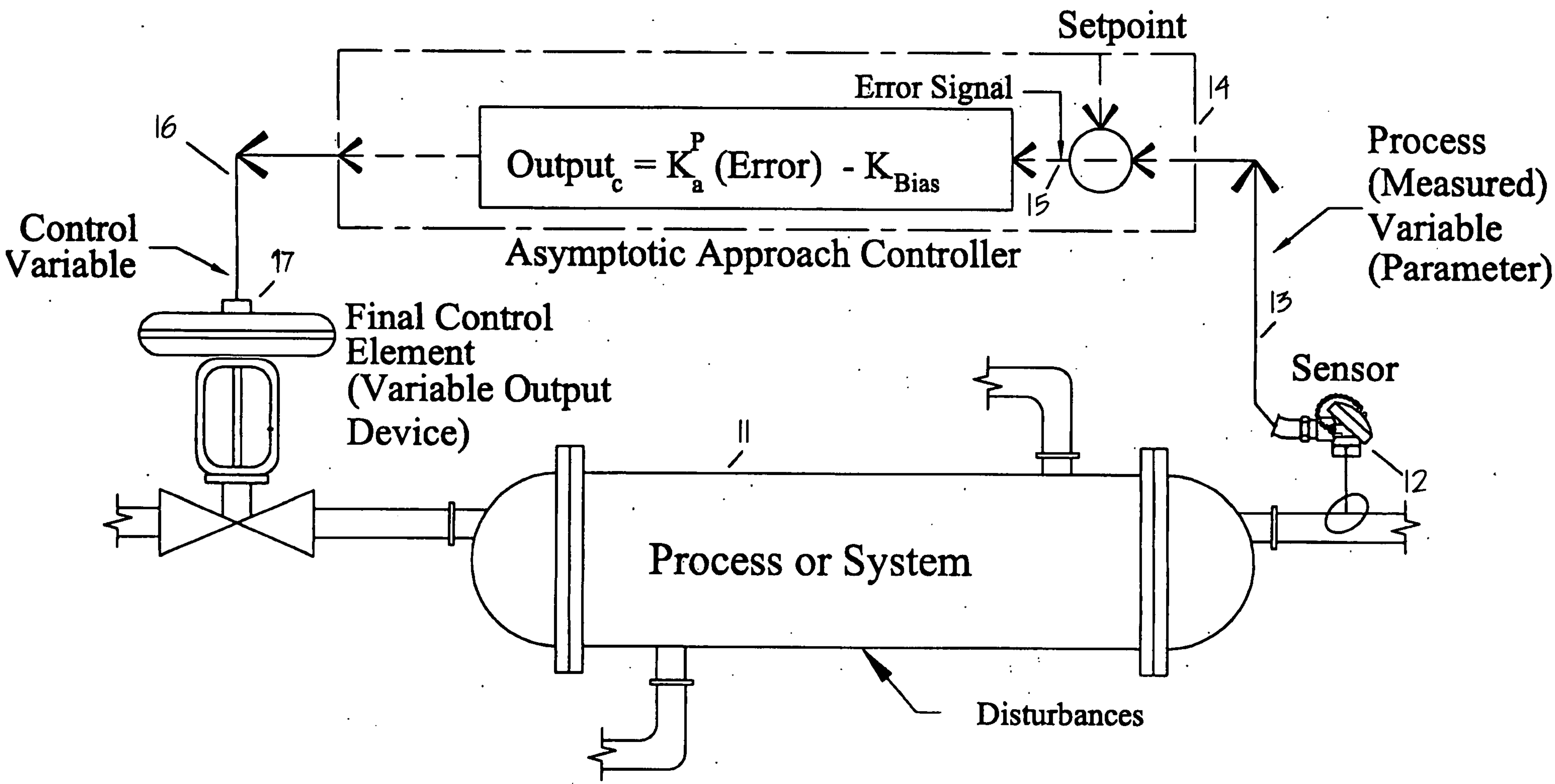

Figure 1: FEEDBACK CONTROL SYSTEM

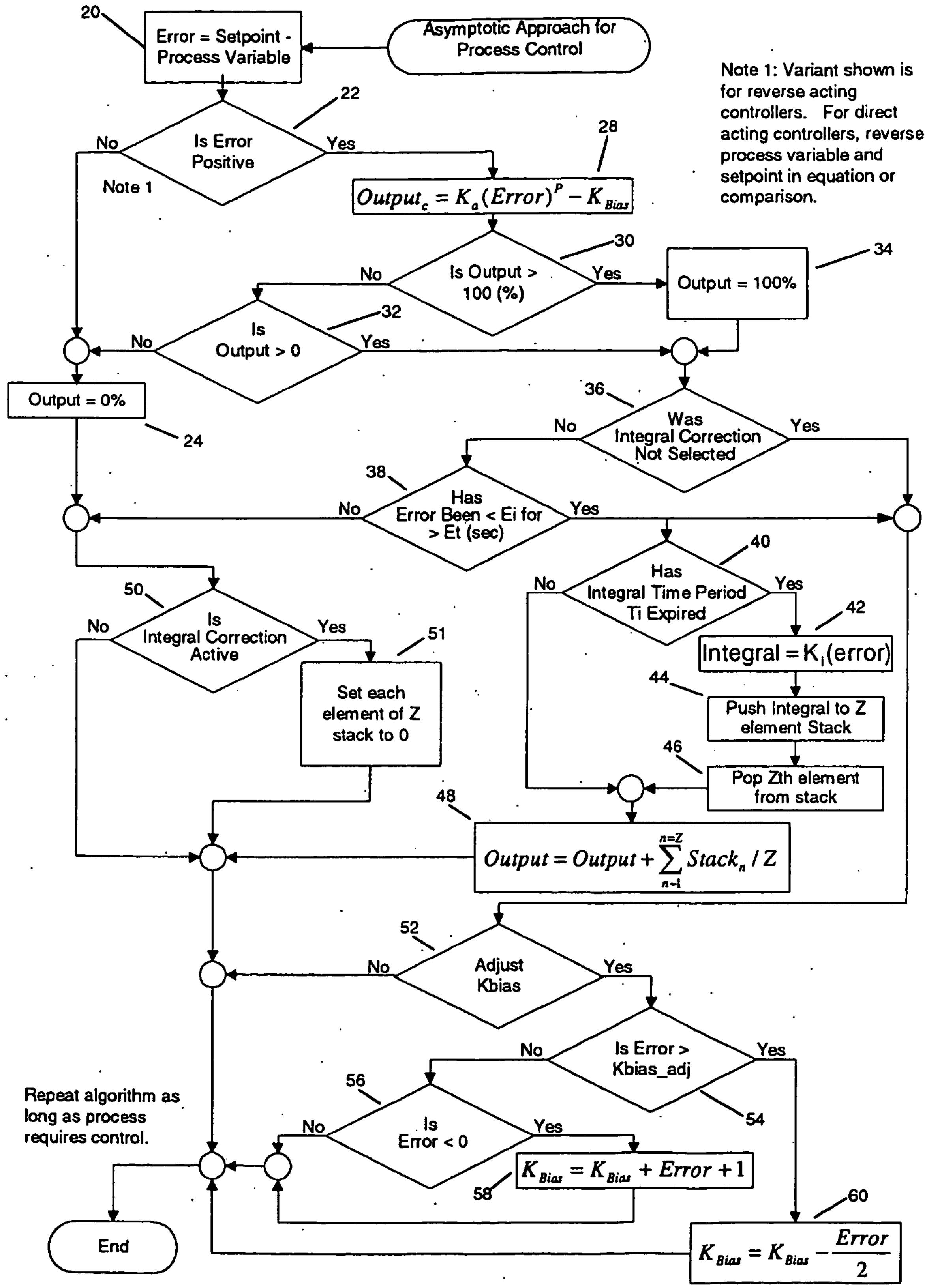

Figure 2: Asymptotic Approach Algorithm Flowchart